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TRITIUM CONTROL AT THE TRITIUM SYSTEMS TEST ASSEMBLY*

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The Tritium Systems Test Assembly (TSTA) is a computer-controlled facility designed to mock up full-scale the deuterium-tritium fuel cycle of next-generation tokamak fusion test reactors. Such reactors will use or build on the experience and technologies of the TSTA and other engineering facilities. The TSTA is presently under construction at the Los Alamos Scientific Laboratory and will be fully operational in 1982.

DESCRIPTION OF THE FACILITY

The TSTA will consist of a gas loop (Fig. 1) and associated control and safety support systems. The loop will include a mock-up torus vacuum chamber followed by cryogenic vacuum and impurity removal systems, a cryogenic hydrogen isotope distillation system, and gas analysis, transfer, mixing and injection systems. The gas loop will be designed to handle a flow of up to $\sim$360 moles of DT per day. This flow will provide operating experience on a scale that is equal to or greater than that of any of the cycles currently being planned for advanced reactors. To accomplish this will require an on-site tritium inventory of $\sim$150 g (1.5 MCi).

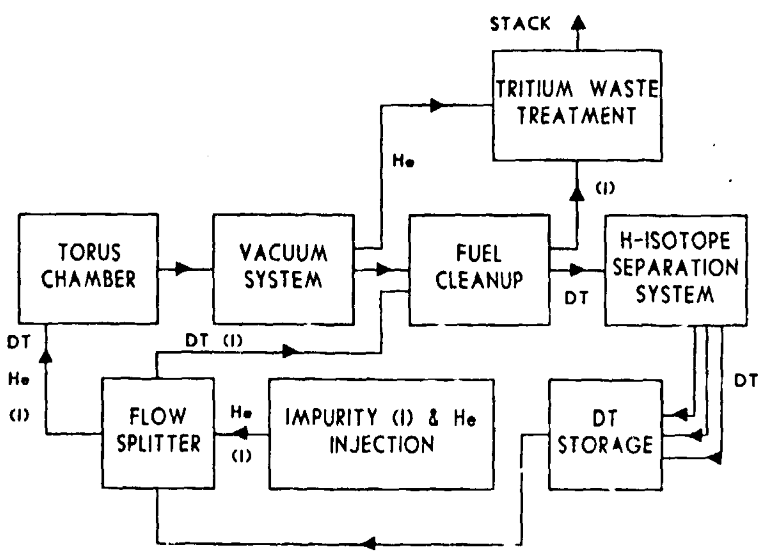

Figure 1. Simplified flow diagram of the TSTA. Note that DT also includes D_2 and T_2.

*Work performed under the auspices of the United States Department of Energy.

The facility is being constructed in an existing steel-frame structure with concrete floor and concrete block walls. The building consists of a large central experimental room (volume: $\sim 3 \; 10^3$ m^3) where the tritium-handling systems will be located, and adjacent areas for the data-acquisition and control computer, mechanical and electrical support equipment, laboratories, shops, and offices.

The main experimental room and two adjacent laboratories where tritium will also be handled are on a separate, once-through ventilation system (4 m^3/s) designed to maintain this area at approximately 0.2 torr negative pressure. The exhaust air will be routed to the outside through a 30-m stack. The remaining rooms will be maintained at 0.2 torr positive pressure by a separate, partly-recirculating ventilation system. The two zones will be connected through air locks which will be maintained at local atmospheric pressure.

An artist's concept of the facility is shown in Fig. 2. Running the length of one side of the main experimental room are two pits 1.5 m deep. Overhead, about 4.5 m above the pit floor, are two steel mezzanines. With the exception of the torus and vacuum systems, all of the tritium handling components of the fuel loop will be located either on the mezzanines or in the pit areas.

DESCRIPTION OF SAFETY SYSTEMS

Two of the principal objectives of the TSTA are to demonstrate that the fuel cycle of a large scale fusion reactor incorporating

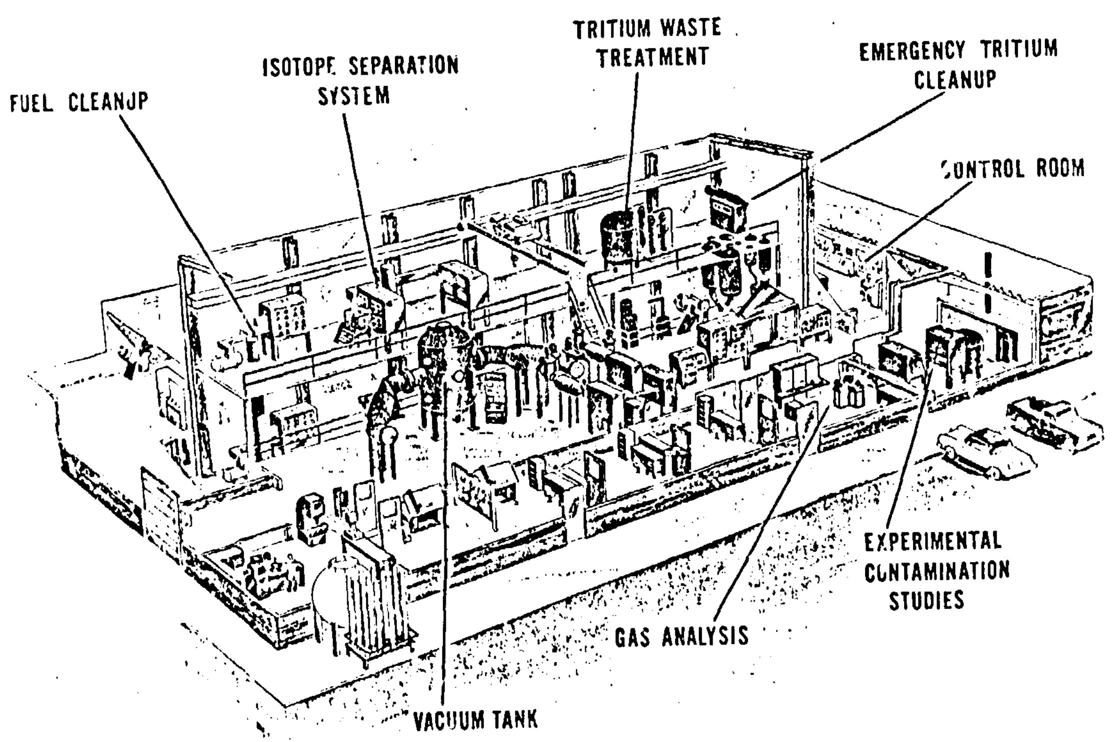

Figure 2. Artist's concept of the TSTA.

large quantities of tritium can be operated reliably and safely. With regard to safety, both for workers and the public, two design goals have been set, that of keeping TSTA personnel exposures below 1 rem/yr and that of maintaining stack effluents below 200 Ci/yr. These goals are the result of attempting to keep all potential exposures to tritium "as low as reasonably achievable." To accomplish these objectives, the TSTA will incorporate a number of safety features.

The first of these is multiple containment. All of the system components which may contain tritium will be doubly contained either by inherent design or by being placed in nitrogen-filled gloveboxes. Exceptions include the torus chamber, some of the associated vacuum system components, and the tritium cleanup systems. Interconnecting lines transporting tritium between sub-systems will be double-walled with one end of the secondary space open to a glovebox.

The TSTA will have two tritium cleanup systems, an on-line system, referred to as the Tritium Waste Treatment System (TWT) and an Emergency Tritium Cleanup System (ETC) for processing tritium releases into the main experimental room. The TWT is a moderate-size batch-type cleanup system with a maximum processing capacity of 32 ℓ/s. Routine tritiated effluents from all of the system components, pumps, etc., as well as releases into gloveboxes can be processed by this system. It incorporates a large receiving tank (5.7 m^3) kept below atmospheric pressure, pre-heater, precious-metal catalyst bed, compressors, high pressure receiving tanks, and molecular-sieve beds. The ETC is a 660-ℓ/s system similar in principle to the TWT but with two main differences: it is a continuous system (as opposed to a batch system), and is designed so that as much as 85% of the moisture in the air may be removed by refrigeration with the remainder removed by molecular-sieve beds. The result is that much smaller beds are required for efficient drying of the processed air. The condensed water can be placed on smaller beds for shipment or disposal or kept as water for recovery of the tritium.

Tritium instruments will help monitor the performance of the TWT and the ETC. All but one will be ionization-chamber monitors with the exception being a scintillation flow-cell monitor in the condensed-water line of the ETC. Glovebox atmospheres will be monitored with instruments equipped with screen-walled ionization chambers to eliminate the need for air pumps, which are often troublesome. The chambers will be covered with felt which will serve as crude dust filters. Seven tritium ionization-chamber instruments will monitor the air of the main experimental area with each instrument monitoring 2-3 points simultaneously. The ventilation exhaust duct will have its own monitor (with added integrating capability) which will be located about 5 seconds in transient time before the air at the monitor reaches a duct isolation valve. Stack monitoring will be performed by a similar ionization-chamber instrument in addition to a bubbler-catalyst-bubbler passive integrating system. The condition of each instrument will be routinely monitored by the computer.

A tritium release into a glovebox will be detected by its monitor, which will be set to alarm at either of two preset levels. The lower-level alarm will prompt only an investigation; with a higher-level alarm, the glovebox atmosphere will automatically be flushed to the TWT. If any one of the room, duct, or stack monitors alarms at its high trip level, the ventilation intake and exhaust duct valves will automatically isolate the room. If a second such instrument similarly alarms, the ETC will automatically begin processing the room air.

For a major release of $\sim 10^6$ Ci of tritium into the room, cleanup of the air is expected to take about 24 hrs. Barring any leaks by permeation or through cracks, the total amount released to the environment should be under 5 Ci.

Experience has shown that at facilities such as the TSTA, the most common tritium exposures result from handling contaminated components during installation, maintenance, or removal of equipment. To minimize this source of exposure, much of the maintenance will be performed either within the gloveboxes where the equipment is located, or in a special glovebox dedicated to this function. Extensive use will also be made of specially designed flexible plastic enclosures equipped with gloves, and plastic suits supplied with breathing air. To eliminate the amount of tritium that would otherwise be released to the room (and might have to be processed by the ETC), the air within these plastic enclosures will be processed by the TWT or a small transportable scrubber if the level of contamination warrants it.

To minimize the risk of a significant loss of tritium to the environment should a release to the experimental room occur during a power failure, two supplementary power supplies will be installed: a diesel-powered 750 kVA emergency motor-generator set and an uninterruptable, battery operated, power supply. All tritium monitors will be on the battery supply as will be the data acquisition and control computer. In addition to supplying power to the ETC, the emergency generator will provide power to the battery supply, all pumps, valves, and other equipment necessary for a partial, temporary shutdown of TSTA. All valves and control equipment are designed to "fail safe" and in the event of complete loss of power, the TSTA would shut down in a safe manner.

Chronic releases to the environment will be under 200 Ci/yr. This will result in a maximum dose at the site boundary of less than 1 mrem/yr and a total local population dose of under 0.2 man-rem/yr.

Major accidental releases to the environment have also been analyzed. One accident scenario that was studied because of the proximity of the facility to the local airport is an aircraft accident involving penetration through the roof of the TSTA building. In the scenario, the inventory of the cryogenic isotope separation system (100 g) is released, oxidized by the accompanying fire and lost to the environment through the roof. With the plume rise from the heated gases, the resultant dose to an exposed person at the site boundary (0.4 km distant) is 1 rem. An unlikely loss of the entire TSTA inventory, oxidized and stacked, would result in a dose of less than 5 rem at the same boundary point. Releases of this magnitude to the environment as a result of damage caused by natural phenomena (tornados, earthquakes) are considered highly unlikely because of the infrequency at Los Alamos of such phenomena of the severity required to cause the necessary damage, and because of the safety features incorporated into the design of the facility.